Spatial Resolution Limits of X-ray Scintillator Crystals

S. Grantham, Z. Levine (RPI/NIST), E. Landree, T. Lucatorto, and T. Jach (NIST)
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Introduction: X-ray imaging incorporating x-ray to visible light conversion has advantages over direct x-ray imaging. Specifically, visible light conversion allows for a larger dynamic range and more compact instrumentation. With the goal of development of an x-ray microscope, the line response of several scinitllators was measured to determine their spatial resolution limit for x-ray energies of 2.2 through 5.0 keV.

Methods and Materials: Scintillator samples included $Bi_4Ge_3O_{12}$ (BGO), $CdWO_4$, Lu_2SiO_5:Ce (LSO), $Y_3Al_5O_{12}$:Ce (0.2%)(YAG), two proprietary crystals (STI-10G and -12.7R). The line response was recorded by illuminating a tungsten knife-edge on each sample with x-rays. These images were recorded by incorporating a CCD camera coupled to a 40x visible light microscope to collect the scintillated light.

Results: The measured line responses varied in width from 2 – 5 μm in width (10-90%). The results of these experiments showed predictions made previously regarding the effect of long x-ray absorption lengths (attenuation lengths of 1 μm or more) on spatial resolution are optimistic. The resulting line response and spatial resolution can be modeled by incorporating a geometrical model of the extended depth of field weighted by the x-ray absorption coefficient of the scintillator host material.

Conclusions: These results further reinforce the need for thin scintillators in high resolution imaging applications. Without thin scintillators, the resolution limit of the visible light imaging optics utilized in a hybrid x-ray imaging system cannot be reailized.

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References: A. Koch et al., J. Opt. Soc. Am. A, **15**, *1940*, 1998.